

WHAT IS CLAIMED IS:

- 1           1. A catheter for removing material from a body lumen, said catheter  
2 comprising:  
3           a catheter body having a proximal end and a distal end;  
4           a material capture device arranged on said catheter body to engage said  
5 material; and  
6           a cutting element mounted near the distal end of the catheter body to move  
7 between a first position and a second position to cut said material while said material is  
8 engaged by said material capture device, wherein motion of the cutting element urges the  
9 material capture device to draw cut material into the catheter body.
- 1           2. A catheter as in claim 1 wherein said catheter body comprises a  
2 proximal, flexible portion and a distal, rigid portion containing said cutting element.
- 1           3. A catheter as in claim 2 wherein said catheter body comprises a  
2 inner cutter mounted coaxially within said distal, rigid portion, said material capture  
3 device mounted on said inner cutter.
- 1           4. A catheter as in claim 2 wherein said catheter body comprises an  
2atraumatic distal tip mounted on said distal, rigid portion.
- 1           5. A catheter as in claim 1 wherein:  
2           said material capture device is arranged on said catheter body to advance  
3 along a path outwardly from the catheter body into said material and then inwardly  
4 towards the catheter body to tension said material; and  
5           said cutting element on said catheter body moving between said first  
6 position and said second position to cut said material while in tension.
- 1           6. A catheter as in claim 5 wherein said path comprises a radially  
2 curved path extending in an outward direction away from the catheter body towards said  
3 material to be cut off.
- 1           7. A catheter as in claim 6 wherein said material capture device  
2 moving along said path does not exceed the outer diameter of the catheter body.

1               8.     A catheter as in claim 5 wherein said material capture device  
2 travels in a slot on the catheter body to advance along said path.

1               9.     A catheter as in claim 5 wherein said material capture device  
2 travels in a groove on the catheter body to advance along said path.

1               10.    A catheter as in claim 5 wherein said material capture device  
2 comprises a bias element to urge said material capture device along said path.

1               11.    A catheter as in claim 5 wherein said material capture device is  
2 configured to rotate about a pivot pin to deploy said material capture device along said  
3 path.

1               12.    A catheter as in claim 1 wherein said material capture device  
2 comprises:

3               a penetrating member pivotably mounted about a pin on said cutting blade,  
4 said penetrating member movable between a first, tissue-engaging position and a second  
5 tissue-retracting position; and

6               a cam surface disposed on said catheter body to contact and rotate said  
7 penetrating member about said pivot point when said cutting blade is advanced over the  
8 cam surface.

1               13.    A catheter as in claim 12 wherein said cam surface is configured to  
2 slidably contact a lower surface on said penetrating member to guide said penetrating  
3 member over an accurate path as the cutting blade is advanced.

1               14.    A catheter as in claim 13 wherein said cam surface includes a  
2 groove for mating with said penetrating member.

1               15.    A catheter as in claim 13 wherein said cam surface includes a first  
2 groove having a funneled opening and a second groove having a second funneled  
3 opening.

1               16.    A catheter as in claim 13 wherein said penetrating member  
2 comprises a recess on said lower surface to facilitate positioning of said member over said  
3 cam surface.

1           17. A catheter as in claim 1 wherein said material capture device  
2 comprises:

3                 a penetrating member rotatably mounted on said cutting element; and  
4                 an abutment disposed on said catheter body to engage one end of the  
5 penetrable member and cause rotation of the penetrating member from a first, open  
6 position to a second, closed position.

1           18. A catheter as in claim 17 further comprising a tether coupled to  
2 said penetrating member to control positioning of the penetrating member.

1           19. A catheter as in claim 1 wherein said material capture device  
2 comprises a penetrating member rotatably mounted on said catheter body and fixedly  
3 secured relative to said slidable cutting element;

4                 a pushing element mounted on said cutting element to engage said  
5 penetrating member to move said member between a first position to a second tissue-  
6 engaging position.

1           20. A catheter as in claim 1 wherein said material capture device is  
2 configured to be deployed from an aperture in the side wall of the catheter body.

1           21. A catheter as in claim 20 wherein said cutting element includes an  
2 material imaging device mounted to be in an imaging position when said aperture is  
3 closed by said cutting element.

1           22. A catheter as in claim 1 wherein said cutting element includes a  
2 first cutting blade having at least one penetrating point.

1           23. A catheter as in claim 1 wherein said cutting element has a first  
2 cutting blade opposed to a second cutting blade for removing said material.

1           24. A catheter as in claim 1 wherein said cutting element comprises a  
2 tubular inner cutter slidably mounted within an outer cutter of the catheter body, said  
3 inner cutter coupled to a drive wire actuated by a user.

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1           25. A catheter as in claim 1 wherein said material capture device  
2 extends an extension distance outward from the catheter body to engage material, said  
3 extension distance equal to the diameter of the catheter body.

1           26. A catheter as in claim 1 wherein said material capture device  
2 includes a barbed distal tip to retain material on the capture device.

1           27. A catheter as in claim 1 wherein said cutting element further  
2 comprises a material imaging device.

1           28. A catheter as in claim 27 wherein said material imaging device  
2 comprises an ultrasound transducer array.

1           29. A catheter as in claim 1 wherein said material capture device  
2 comprises means for penetrating said material.

1           30. A catheter as in claim 29 wherein said means for penetrating  
2 material comprises a curved needle biased outwardly from the catheter body.

1           31. A catheter as in claim 29 wherein said means for penetrating  
2 material comprises a penetrating member rotatably mounted about a pivot pin on said  
3 cutting element.

1           32. A catheter as in claim 29 wherein said means for penetrating  
2 material is configured to engage a raised portion on said catheter body to move said  
3 means to engage material and then retract material into the catheter body.

1           33. A catheter as in claim 32 wherein said raised portion comprises a  
2 cam surface having a plurality of tracks, wherein each track has a funneled entrance to  
3 guide said penetrating member therein.

1           34. A catheter for removing material from the wall of a body lumen,  
2 said catheter comprising:

3            a catheter body having a proximal end and a distal end;  
4            a side aperture on the catheter body;  
5            a cutting blade adapted to advance past the aperture to sever material  
6 which intrudes through the aperture; and

7                   a penetration member mounted to extend through the aperture to penetrate  
8 material in advance of the cutting blade and to draw material into the catheter body as the  
9 cutting blade is advanced past the aperture.

1                 35. A catheter as in claim 34 further comprising a cam surface  
2 mounted on said catheter body, said cam surface having a surface configured to guide  
3 said penetration member into said material when said blade is advanced.

1                 36. A catheter for removing material from a body lumen, said catheter  
2 comprising:

3                   a catheter body having a proximal end and a distal end;  
4                   a material capture device arranged on said catheter body to advance along  
5 a path radially outwardly from the catheter body into said material and then inwardly  
6 towards the catheter body to tension said material; and

7                   a cutting element on said catheter body moving between a first position  
8 and a second position to cut said material while said material is in tension.

1                 37. A catheter for removing material from a body lumen, said catheter  
2 comprising:

3                   a catheter body having a proximal end, a distal end, and an aperture;  
4                   a slidably, telescoping portion on said catheter body configured to extend  
5 outwardly from said aperture on the catheter body, said telescoping portion having a first  
6 open position leaving a gap between one edge of said portion and said catheter body to  
7 define a cutter window in which material may intrude to be engaged and having a second  
8 closed position wherein said cutting blade is positioned to cut off said material.

1                 38. A catheter as in claim 37 wherein said gap defines a side-opening  
2 cutter window.

1                 39. A catheter as in claim 37 wherein said aperture comprises a  
2 forward facing, distal aperture on the catheter body.

1                 40. A catheter as in claim 37 further comprising a material capture  
2 device mounted on said telescoping portion, said portion moving between a first position  
3 and a second position to cut said material while said material is engaged by said material

4 capture device, wherein motion of the telescoping portion urges the material capture  
5 device to draw cut material into the catheter body.

1           41. A catheter as in claim 40 wherein said material capture device is  
2 rotatably mounted to said telescoping portion and configured to engage a raised portion  
3 on said catheter body to rotate said material capture device to engage material and then  
4 draw material into the catheter body.

1           42. A method for excising occlusive material from within a body  
2 lumen, said method comprising:

3                 capturing said occlusive material with a material capture device on a  
4 catheter body;

5                 drawing said device radially inwardly towards the catheter body to tension  
6 the material; and

7                 advancing a blade through the tensioned material to sever said material  
8 from the body lumen.

1           43. A method as in claim 42 wherein said engaging of said occlusive  
2 material comprises extending said material capture device from said catheter body in a  
3 radially outward direction.

1           44. A method as in claim 43 wherein said material capture device does  
2 not extend beyond the outer diameter of the catheter body when engaging said material.

1           45. A method as in claim 42 wherein said engaging of said occlusive  
2 material comprises penetrating said material with said material capture device.

1           46. A method as in claim 42 wherein said engaging of occlusive  
2 material comprises radially extending said material capture device outward from an  
3 aperture on the catheter body.

1           47. A method as in claim 46 wherein said engaging of said occlusive  
2 material comprises guiding said material capture device against a raised portion on the  
3 catheter body to direct said capture device into said material.

1           48. A method as in claim 46 wherein said engaging of said occlusive  
2 material comprises advancing said cutting blade to engage a pushing element against said  
3 material capture device mounted on the catheter body.

1           49. A method as in claim 46 wherein said engaging of said occlusive  
2 material comprises penetrating said material in advance of the blade and said drawing of  
3 said device into the catheter body occurs as the cutting blade is advanced past the  
4 aperture.

1           50. A method as in claim 46 further comprising imaging said material  
2 prior to cutting said material, wherein said imaging occurs when said aperture is closed  
3 by said cutting blade.

1           51. A method as in claim 42 wherein said drawing of the device  
2 comprises moving said material capture device radially towards said catheter body while  
3 said material capture device remains in contact with said material.

1           52. A method as in claim 51 wherein said drawing of said material  
2 capture device occurs when said cutting element is advanced, said cutting element  
3 pushing against said material capture device and biasing it into the catheter body.

1           53. A method as in claim 51 wherein drawing of said material capture  
2 device comprises positioning said material capture device against a raised portion on the  
3 catheter body to guide said device with the material into the catheter body.

1           54. A method as in claim 42 wherein said engaging and tensioning of  
2 material are performed through a single motion by the user.

1           55. A method for removing material from a body lumen, said method  
2 comprising:

3                 positioning a catheter within the lumen;  
4                 extending a distal portion of the catheter forwardly to open an aperture,  
5 wherein material is invaginated into the aperture; and  
6                 closing the distal portion of the catheter to close the aperture and sever the  
7 invaginated material.

1                   56. A method as in claim 55, wherein the body lumen is a blood vessel  
2 and the material is atherosomatous material.

1                   57. A method as in claim 55, further comprising penetrating the tissue  
2 with a material capture device and drawing the captured material into the aperture with  
3 the device as the distal portion of the catheter body is closed.

1           58. A kit comprising:  
2            a catheter having a material capture device and a cutting element;  
3            instructions for use in removing material from a body lumen comprising  
4           engaging said material with a material capture device and tensioning said material  
5           towards the catheter while cutting said occlusive material with a cutting element; and  
6            a package adapted to contain the device and the instructions for use.

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